

# NHDOT SPR2 PROGRAM

## RESEARCH PROGRESS REPORT

### INSTRUCTIONS:

*Project Managers and/or research project investigators should complete a progress report at least every three months during the project duration. Reports are due the 5<sup>th</sup> of the month following the end of the quarter. Please provide a project update even if no work was done during this reporting period.*

<b>Project #</b> 26962M		<b>Report Period</b> Year: 2017 <input checked="" type="checkbox"/> Q1 (Jan-Mar) <input type="checkbox"/> Q2 (Apr-Jun) <input type="checkbox"/> Q3 (Jul-Sep) <input type="checkbox"/> Q4 (Oct-Dec)	
<b>Project Title:</b> Evaluation of Gusset-less Truss Connection to Aid Bridge Inspection and Condition Assessment			
<b>Project Investigator:</b> Erin S. Bell <b>Co-Project Investigator:</b> Ricardo Medina <b>Phone:</b> (603)862-3850 <b>E-mail:</b> erin.bell@unh.edu			
<b>Research Start Date:</b> December 15, 2016	<b>Research End Date:</b> December 31, 2018	<b>Project schedule status:</b> <input type="checkbox"/> On schedule <input type="checkbox"/> Ahead of schedule <input checked="" type="checkbox"/> Behind schedule	

### Brief Project Description:

The Memorial Bridge connecting Portsmouth, NH and Kittery, ME was re-opened to traffic in 2013. One of the major innovations of the reconstructed bridge is the first ever gusset-less truss connection in a vehicular bridge in the United States. Traditional gusset plates are the most vulnerable element in a truss-bridge structure and a source of significant cost, effort, and concern for bridge managers and owners. The goal of the proposed research is to integrate field-collected performance data, laboratory experimental testing, and physics-based structural modeling to develop a protocol to assess the condition and predict the remaining life of the gusset-less truss connections used at the Memorial Bridge. It is anticipated that the aforementioned approach will be modified to develop a framework to extend this protocol for application to future innovative structural elements.

The objectives of this project are to:

- Create two specimen pairs (A and B) of a scale model of a gusset-less connection from the Memorial Bridge. Specimen pair A (top chord connection) will be tested to failure in a quasi-static testing protocol and Specimen pair B (bottom chord connection) will be tested for fatigue performance.
- Conduct quasi-static set of tests on each member of Specimen pair A to determine stress distribution in the connection.
- Evaluate these results in conjunction with field collected data and analytical models that are the work product of a complimentary FHWA-AID DEMO project to: (i) further understand and quantify the structural performance of the gusset-less connection, and (ii) validate analytical models.
- Conduct fatigue testing on Specimen pair B and collect performance data to determine the stress pattern and predict fatigue failure mode.
- Compare the findings of this project with the FHWA guideline for connection assessment to facilitate the development of an evaluation protocol for inspection and structural condition assessment.

**Progress this Quarter (include meetings, installations, equipment purchases, significant progress, etc.):**

### Literature Review and Finalize Testing Plan

This literature review and testing plan was started as part of PI Bell's graduate course in advanced steel design and has continued in the spring as part of co-PI Medina's experimental structural dynamics class. This literature review has included an evaluation of the summary calculations for the gusset-less connection provided by HNTB, which were made

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available to the research team after the project proposal was submitted. A graduate student, Fernanda Fischer, will complete this task by May 2017 as a funded graduate research assistant in spring 2017.

### **Design and Construction of Small-scale Physical Models**

A plate buckling specimen was designed as part of the advanced steel graduate course in fall 2016. This specimen was fabricated in February 2017 and will be tested as part of the experimental structural dynamics by May 2017.

### **Analytical Models of Small-scale Physical Specimens**

Preliminary models for the gusset-less connection and plate buckling specimen were created as part of the advanced steel design course in fall 2016. These models will be calibrated with test data over the course of the first year of this project. After the first TAG meeting (March 28<sup>th</sup> 2017), the testing plan was modified to test the strength of the connection element not to failure. This will allow the use of larger physical specimens and will impact the design of the test setup.. A decision was made to keep the bend radius constant at 16t, which is the bend radius used in the gusset-less Memorial Bridge connection, and test configurations with a different plate thickness, t, instead.

### **Quasi-Static Testing**

An initial evaluation of testing alternatives to conduct the quasi-static test was performed using the loads obtained from the HNTB summary calculations. The main testing limitations relate to the capacity of the fatigue-rated actuator at UNH (110 kips) and the configuration of the existing testing frame (to support the actuator). Preliminary calculations and drawings for the test set up were presented in the first TAG meeting (March 28<sup>th</sup> 2017). During the meeting, a decision was made not to test physical models of a connection at the top chord to failure, for the bridge was designed to experience buckling failure of the diagonals before buckling of the connection panel zone region were to occur.

### **Validation of Structural Connection Analytical Model**

There was no progress on this task during this reporting period.

### **Fatigue Testing**

An evaluation of the summary design calculations produced by HNTB, which include results from finite element analysis of gusset-less connections at the lower chord, was conducted to identify expected critical areas of stress concentration for fatigue analysis and testing. The calculations were helpful to identify trial design configurations that would be useful to finalize the geometry of the specimen pairs B. A discussion ensued in the March 28<sup>th</sup> TAG meeting on the possibility of adding test on the weld alone and/or on single bent plates.

### **Data Analysis and Interpretation of Laboratory Testing**

There was no progress on this task during this reporting period.

### **Evaluation Protocol for Inspection and Condition Assessment**

There was no progress on this task during this reporting period.

### **Final Report and Presentation**

There was no progress on this task during this reporting period.

### **Items needed from NHDOT (i.e., Concurrence, Sub-contract, Assignments, Samples, Testing, etc ):**

There are no items needed from the NHDOT at this time. The research team would like to request a TAG meeting to review the testing plan in May 2017.

### **Anticipated research next 3 months:**

NHDOT SPR2 Quarterly Reporting

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Finalize literature review.

Test the plate buckling specimens for model verification and calibration.

Use field data for the strain gauges installed at the Memorial Bridge to calculate the stress range that should be used for fatigue testing.

Complete the design of test specimens and setup for both quasi-static and fatigue testing.

Coordinate with CANAM Bridge for specimen fabrication.

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**Circumstances affecting project:** Describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope, and budget, along with recommended solutions to those problems.

As described in the “Progress this Quarter” section of this report, the schedule delay and increased cost related to the electrical conduit negatively impact this project.

Tasks (from Work Plan)	Planned % Complete	Actual % Complete
<b>Evaluation of Gusset-less Truss Connection to Aid Bridge Inspection and Condition Assessment</b>		
Literature Review and Finalize Testing Plan	75	50
Design and Construction of Small-scale Physical Models	50	25
Quasi-Static Testing to Failure	0	0
Validation of Structural Connection Analytical Model	0	0
Fatigue Testing	0	0
Data Analysis and Interpretation of Laboratory Testing	0	0
Evaluation Protocol for Inspection and Condition Assessment	0	0
Final Report and Poster	0	0